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13. ABSTRACT (Maximum 200 words)

This report describes in general terms the Investigator's research on the effect of ocean fluctuations on sound transmission, during the contract period, May 1987 to September 1989. This report contains a listing of five (5) papers published in the open refereed literature on subject research.

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THE EFFECT OF OCEAN FLUCTUATIONS ON SOUND TRANSMISSION IN THE OCEAN

FINAL TECHNICAL REPORT

May 15, 1987 to September 30, 1989

Contract No. N00014-87-C-0445

Principal Investigator: Stanley M. Flatté

SUMMARY

The objective of this work was to use a general theoretical framework for calculating fluctuations of signals on waves propagated through random media (WPRM) for two purposes: first, to compare with experimental data in as wide a variety of cases as possible, and second, to develop ocean acoustics as a probe of ocean fluctuations, particularly internal waves.

This report will consist of a summary (with list of references), followed by copies of the journal articles resulting from this contract that have been published.

The work has been carried out under the direction of Dr. Stanley Flatté, and involved effort by Dr. Flatté; post-doctoral researchers J. Martin, and T. Duda; a number of graduate students; former student Dr. R. Stoughton of SAIC; and a number of collaborators from other institutions.

During the period of the contract, we finished our publication of results from the AFAR experiment.[1,2]

We also were invited to contribute the lead article to a special issue of Applied Optics on Wave Propagation in Random Media; we presented results of numerical simulations of propagation through 3D random media, by use of a supercomputer.[3]

In 1982, the Principal Investigator suggested the use of long-range acoustic propagation as a probe of the internal-wave spectrum.

Pulses sent through a fluctuating medium arrive earlier or later than they would in the absence of fluctuations, depending on the particular realization of the medium. The variance of arrival time can be calculated by straightforward methods in the geometrical optics limit. This variance is a direct probe of the internal-wave spectrum in the ocean. The feasibility of such a method was established in 1986 with the publication of the first measurement of the internal-wave spectrum using ocean acoustic transmissions.

During the contract period, calculations were made of specific internal-wave effects on ocean acoustic measurables for a realistic experimental arrangement with 1000-km range and low frequency. The results were intended to apply to an experiment done in the summer of 1987. The calculations were published.[4]

Several results have been obtained during the contract period that have not yet been written up for publication. Results from the 1987 experiment at single frequencies (rather than with pulses) were analysed in terms of very simple two-ray, geometrical-optics models, and qualitative agreement with important features in the data was obtained. This led to a development of a ray-theory model for the complete single-frequency field from a point source.

The principal investigator has emphasized that a ray-theory model of propagation is important because it provides a broad-band model capable of explaining pulse propagation in a simple way, and because it is the basis for tomography techniques that depend on understanding the ocean sampling for each measurement made (for example, of the travel time fluctuation for a given ray).

We have recently expanded the ray-theory model to treat not just single rays, but wavefronts. This concept is crucial for the development of understanding of the results of vertical-array experiments across the ocean sound channel, and for understanding the effects of internal waves on long-range sound-channel propagation.

We have contributed to the design and planning for two other ocean acoustics experiments. First, we collaborated with Harry Deferrari on a high-repetition-rate experiment to observe internal waves in the Atlantic off Florida. So far this experiment has been unsuccessful, though it involved a great deal of preparation work. Second, we helped with the summer 1989 VAST-I experiment in the Pacific. The planning for sections of the experiment to use a tomography pulsed source, and to look at internal waves, was influenced by our involvement.

Finally, we have published our analysis of Arctic high-frequency, short-range propagation models, with comparisons to the results of Garrison and Wen. In nearly all cases, in order to compare theory to experimental data in WPRM, we must use a model spectrum for the medium fluctuations. We have developed phenomenological spectra, as a function of wave vector, that allow for an anisotropic component added to a turbulent isotropic component.[5]

During the contract period, Dr. Flatté and Dr. Duda attended numerous meetings of the Acoustical Society of America, the American Physical Society, and the American Geophysical Union, at which much of the above work was presented in the form of talks and posters.

In June, 1988, Trent Moody received his Ph.D. with partial support from this contract. The title of his thesis was *Wave propagation through random media: an investigation of two-frequency intensity statistics.* During the last year of the contract, two new students have begun working on ocean acoustics under Dr. Flatté; they are John Colosi and Charles Bracher. They will be involved in the analysis of data from new ocean acoustics experiments recently completed.

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